

VISIBLE AND NEAR-IR REFLECTANCE SPECTRA OF MARS ANALOGUE MATERIALS UNDER ARID CONDITIONS FOR INTERPRETATION OF MARTIAN SURFACE MINERALOGY. R. V. Morris¹, T. G. Graff², C. N. Achilles², D. G. Agresti³, D. W. Ming¹, and D. C. Golden². ¹ARES NASA Johnson Space Center, Houston TX 77058 (richard.v.morris@nasa.gov), ²Jacobs Technology ESCG, Houston, TX 77058, ³University of Alabama at Birmingham, Birmingham AL 35294.

Introduction: Visible and near-IR (VNIR) spectra from the hyper-spectral imagers MRO-CRISM and Mars Express OMEGA in martian orbit have signatures from Fe-bearing phases (e.g., olivine, pyroxene, and jarosite), H₂O/OH-bearing phases (e.g., smectites and other phyllosilicates, sulfates, and high-SiO₂ phases), and carbonate [e.g., 1-5]. Mineralogical assignments of martian spectral features are made on the basis of VNIR spectra acquired in the laboratory under appropriate environmental conditions on samples whose mineralogical composition is known. We report here additional results for our ongoing project [6] to acquire VNIR spectra under arid conditions.

Samples and Methods:

Our focus here is 14 H₂O/OH bearing phases. Samples containing primarily OH are KGA-1 (kaolinite; Georgia), SRPSLO1 (serpentine, CA), CHLCLV1 (chlorite, CA), and IMT-1 (illite, MT). Samples containing both OH and H₂O are CBZAZ1 (chabasite, AZ), HWMK919 (palagonite, HI), API-33A (nontronite, WA), PHY07 (nontronite, PA), NAU-1 (nontronite, Australia), SWA-1 (ferruginous smectite, WA), SWY-1 (montmorillonite, WY), STX-1 (montmorillonite, TX), BSDMNT1 (bentonite, SD), and SAPCA-1 (saponite, CA). All samples were fine powders (<150 μ m) except HWMK919 (<5 μ m) and PHY07 (<38 μ m).

VNIR spectra were acquired at ~25°C with an Analytical Spectral Devices (ASD) FeildSpec3 spectrometer that was located inside a one-atmosphere glove box that was purged with dry-N₂ gas (from liquid N₂). A hot plate (ambient to 400°C), a dewpoint meter to measure the H₂O content of the gas atmosphere (Vaisala DRYCAP DM70), and an IR thermometer (Fluke Model 66) were also in the glove box.

A typical experiment sequence was to: (1) load samples into a Al-metal sample cup (painted with optical black paint) and acquire spectra in the glove box under ambient lab conditions (**blue**); (2) acquire spectra at ~25°C after a known time of N₂ purge with the sample at ~25°C (**green**); (3) acquire spectra at 25°C after a known time of purging with the sample at ~110°C (**brown**); (4) acquire spectra at 25°C after a known time of N₂ purge with the sample at ~210°C (**red**); and (5) acquire a spectrum at 25°C after a known time in laboratory air with the sample at 25°C (**dark blue**). The post-heating measurements were

done as soon as the sample cooled to 25°C. Typically, the H₂O content of the glove box was ~80 to ~140 ppmv at the end of steps (2), (3), and (4). We estimate an ~20 ppmv O₂ content from measurements in a separate chamber that was N₂-purged in the same way. The time intervals for each step are summarized in Table 1.

Backscatter Mössbauer (MB) spectra were acquired at room temperature using MER-like MIMOS-II spectrometers from SPESI [c.f., 7]. MB measurements were made on bulk sample inside air-tight plastic containers that were filled with sample inside the glove box.

Table 1. Time at temperature during step-wise heating in a dry N₂ purge atmosphere and time since exposure to lab air.

Sample	Type ^a	2: N ₂ ^b , 25°C ^d	3: N ₂ ^b , 110°C ^d	4: N ₂ ^b , 210°C ^d	5: Air ^c , 25°C ^d
		(hr)	(hr)	(hr)	(hr)
API-33A	nont	263	1206	336	6239
NAU-1	nont	263	1206	336	6239
PHY07	nont	410	1944	89	8736
SWA-1	nont	263	1206	336	6239
KGA-1	kaol	428	928	796	24
SWY-1	mont	168	840	336	2692
STX-1	mont	168	840	336	2692
BSDMNT1	bent	168	840	336	2692
SAPCA-1	sapn	168	840	336	2692
IMT-1	ilit	168	840	336	2692
SRPSLO1	serp	428	928	796	---
CHLCLV1	chlr	428	928	796	24
CBZAZ1	zeol	428	928	796	24
HWMK919	palg	428	928	796	24

^anont = nontronite, mont= montmorillonite, bent = bentonite, kaol = kaolinite, sapn = saponite, chlr = chlorite, serp = serpentine, zeol = zeolite, palg = palagonite.

^bN₂ gas atmosphere with 80 – 140 ppmv H₂O and ~15 ppmv O₂ at ~25°C at the end of each step.

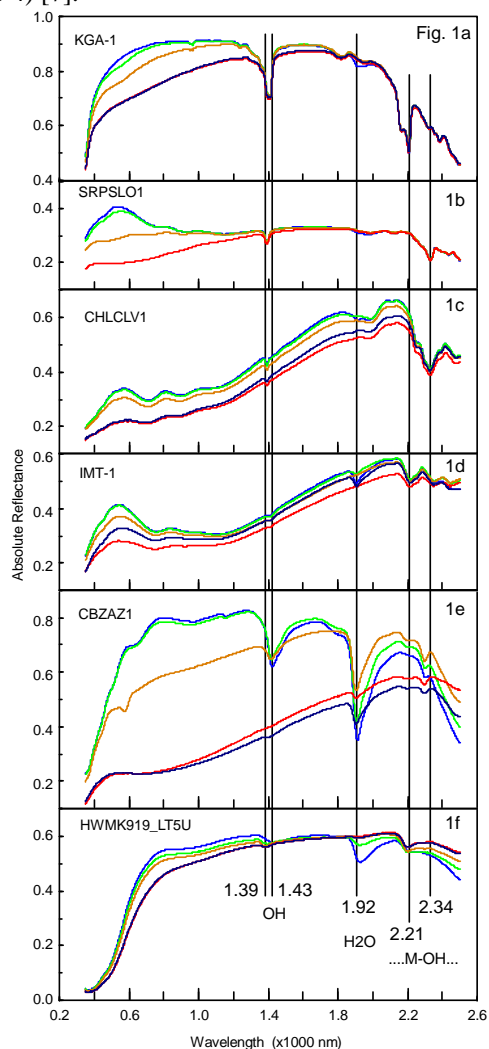
^cLab air atmosphere with 8000 – 13000 ppmv H₂O.

^dSample temperature in N₂ or air atmosphere.

Results and Discussion: The OH spectral features of the OH-only samples (KGA-1, SRPSLO1, CHLCLV1, and IMT-1) do not significantly change in an arid environment, as expected (Fig. 1a - 1d). The zeolite (CBZAZ1) does appear to loose some H₂O, as can be seen by comparison the red and dark blue spectra at ~1.92 μ m (Fig. 1e). The palagonite lost all detectable H₂O (no 1.91 μ m band; red spectrum; Fig. 1f).

The samples in Fig. 2 are all smectites, and thus have both M-OH and interlayer H₂O. With increasing loss of H₂O (decreasing intensity of the ~1.91 μ m band), the position of the 1.40 μ m band shifts in accordance with a higher contribution of OH from M-OH than from H₂O (e.g., Fig. 2g). Note that all smec-

tites re-acquire their interlayer H₂O upon exposure to lab air (step 5). Powder X-ray diffraction data show that the interlayer is fully collapsed for the nontronites (step 4) [7].



All spectra show to varying degrees a decrease in albedo in the region between ~ 0.4 and $1.7 \mu\text{m}$ by the end of step 4. The change is especially evident for the zeolite (Fig. 1e) and the smectites (Fig. 2). Furthermore, this decrease is still present after prolonged exposures to humid lab air (step 5). A possible explanation is precipitation of ferric oxide particles during the thermal treatments. However, MB evidence (not shown) for this explanation is not compelling.

The spectra that result from thermal treatments at 25°C, 110°C, and 210°C (Fig. 1 and Fig. 2) in arid atmospheres for laboratory timescales are reasonable surrogate spectra for geologic timescales on Mars at lower temperatures.

References: [1] Bibring *et al.* (2006), *Science*, 312, 400. [2] Poulet *et al.* (2005), *Nature*, 438, 623.

[3] Mustard *et al.*, *Nature*, doi:10.1038/nature07097, 305. [4] Milliken *et al.* (2008) *Geology*, 36, 847. [5] Ehlmann *et al.* (2008) *Science*, 322, 1828. [6] Morris *et al.* (2009) *LPSC40*, Abs. #2317. [7] Morris *et al.* (2011) this volume.

